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Research about the relationship between the health, economic development and public health expenditure----Evidence: From 11 coastal cities in China

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Abstract: This paper firstly makes a statement on the necessity of this topic and the practical significance behind it. Then it combs through the relevant theories and literature on health capital, public health expenditure, health economics, and economic growth, and analyses the impact and effect of public health expenditure on health capital as well as economic growth in light of scholars' explorations and findings. By collecting relevant data in recent years in Beijing, China, the impact of public health expenditure on economic growth is explored using econometric methods with Beijing as the main research object. The explanatory variable is public health expenditure, the explanatory variables are health capital and economic growth situation in Beijing, and the rest of the control variables are environment, education, and social situation. According to the data relationship between the explanatory variables and the explanatory variables, the authors put forward different research hypotheses and establish different regression models respectively, so as to explore their correlation. The results of the study show that: Beijing government health expenditure has a great role in promoting health capital, and there is still much room for the government to improve it at present; public health expenditure has a significant positive impact on the economy of Beijing, indicating that increasing public health expenditure helps to promote economic growth, which provides theoretical support and empirical evidence for further improvement of public health policy. Finally, on the basis of empirical analysis, this paper puts forward policy recommendations to increase public health expenditure and improve health capital level in Beijing, so as to promote the economic growth of Beijing based on the correlation between the actual health expenditure, health capital and economic growth in Beijing.

Keywords: health economics; public health expenditure; economics growth;

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1. Introduction

With its large population and complex geography and demographics, China faces major challenges in maintaining a balanced supply of health services across regions. The effectiveness of health services is not only crucial for improving quality of life but also a test of the government's management capacity (Zhao, 2012). Since the founding of the People's Republic of China (PRC) in 1949, China's health system has undergone extensive changes and evolved through a variety of economic models, each of which has left a distinctive mark on the country's health care.

During the planned economy era, China spent approximately 3 percent of its GDP on healthcare, successfully meeting the basic healthcare needs of nearly all its citizens.

This period was characterized by strong government support, which facilitated universal access to basic healthcare, even for low-income populations - a point highlighted in discussions of rural healthcare payments by Jean Dreze and others before China's economic reforms. However, over the past three decades of transition to a market economy, the Chinese government has invested relatively less in health. This decline has caused multiple problems as health indicators have begun to lag behind other areas of development and in some cases even regress (Wu, 2014). The contrast between rapid economic development and slow improvement in health indicators is alarming. A 2003 survey by the Ministry of Health highlights this disparity:48.9 percent of urban and rural residents in need of medical care did not seek it due to financial constraints; 29.6 percent of patients in need of hospitalization never received it; and 43.3 percent of hospitalized patients were discharged prematurely. In addition, financial constraints force more than 60 percent of patients to leave hospitals earlier than recommended by their doctors; in remote areas, nearly 62 percent of patients choose not to receive the necessary treatment, and 75.1 percent leave hospitals before fully recovering. These statistics highlight a systemic problem - despite growing economic prosperity, public health spending has not kept pace, influenced in large part by an ideology that prioritizes treatment over prevention. In recent years, the Chinese government has placed unprecedented emphasis on healthcare reform. Efforts have focused on addressing the difficulties associated with health insurance and the high cost of accessing medical services, with the aim of raising the standard of public health services. Since 2003, there has been a growing recognition of the role of government in providing adequate public services. However, challenges remain due to insufficient funding for public health, an irrational system of fiscal decentralization, and a flawed system of transfers, which together have led to a steady decline in the share of public health funding in the national budget. These fiscal constraints are further exacerbated by the earmarking of funds for purposes other than those for which they were intended.

This background sets the stage for this study, which aims to investigate the relationship between public health expenditure, health outcomes, and economic growth. By analyzing the dynamics of public health spending and its impact on the wider economic landscape, this study aims to provide valuable insights into how health investment can act as a catalyst for economic development, with a particular focus on the coastal context. This exploration is critical not only for policy formulation but also for understanding the broader impact of health spending in driving sustainable economic growth.

Understanding how to measure the impact of public health expenditures on economic growth is a crucial area of research. In China, much of the existing literature on health spending focuses primarily on descriptive analyses of government health expenditures. Zhu (2002) argues that government investment in health is often viewed solely as welfare consumption, without recognizing its potential contribution to investment in human capital. This view may overlook the broader economic impact of health investments. A key model by Bloom, Canning and Sevilla (2004) illuminates economic growth through the lens of factor inputs, technological innovation, and technology diffusion. They find that health has a significant positive impact on economic growth, suggesting that for every year of increase in population life expectancy, output increases by 4 percent. This finding underscores the significant impact of improved health on economic productivity. Swift (2011) further supports this view by arguing that increased healthcare spending not only improves the quality of care but also extends life expectancy, which ultimately increases worker efficiency and productivity. The general consensus in the literature is that there is a positive correlation between public health expenditures and population health, suggesting that investments in health may also drive economic growth. However, the impact of health and education expenditures on GDP is not uniform across countries, as the study by Maitra and Mukhopadhyay (2012) shows. They used cointegration and panel error correction to examine the Asia-Pacific region from 1981 to 2001, revealing different impacts in different country contexts. Suhrcke et al. (2006) emphasized that health spending

is seen as a strategy to promote economic growth in many countries, despite varying causality and periods. This understanding supports the relevance of empirical research, especially in the Chinese context, where the need for adequate health resource inputs to address the country's public health and healthcare needs remains a pressing issue and a focus of national and international research.

Given these insights, this study aims to construct a nuanced relationship between public health expenditure, health capital, and economic growth. By doing so, it seeks to inform policymakers that public health investment in China may not be merely a public goods consumption behavior, but a strategic investment that can contribute to economic growth and generate significant externalities.

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2. Literature Review

Much of the literature has explored the relationship between public health expenditure, health outcomes, and economic development. While global studies are extensive, there is limited research specific to China. Generally, scholars agree that increased public health spending improves health outcomes, though some dissent.

2.1. Public Health Expenditure and Health

Jamison et al. (1996) found that public health expenditures reduced under-five mortality rates in Latin American countries, a conclusion supported by Orji et al. (2021) in Nigeria. In China, Uchimura and Jutting (2009) linked fiscal decentralization to lower infant mortality. Conversely, Alimi et al. (2023) found that public health expenditure improved long-term life expectancy but did not significantly affect infant mortality. Studies in Africa by Akinkugbe and Mohanoe (2009) and Novignon et al. (2012) also supported the positive impact of health expenditure on outcomes such as life expectancy and reduced mortality. Similarly, Ammi et al. (2024) showed that in Canada, a 1% increase in public health expenditure correlated with a 0.22% reduction in preventable mortality.

However, some scholars disagree. Le Grand (1987) and Berger and Messer (2002) observed weak or negligible effects of public health expenditures on health outcomes. Wolfe (1986), and Tanzi and Schuknecht (1997) concluded that such expenditures had minimal impact on health.

2.2. Public Health Expenditure and Economic Development

There is significant research on the impact of public health expenditure on economic growth. Elmi and Sadeghi (2012) found a long-run association between health expenditure and economic growth in developing countries. Bhargava et al. (2001) showed that health improvements positively impacted GDP growth rates in low-income countries. In the United States, Helms (1985) found that public health expenditure stimulated economic growth. In China, Luo (2011) and Lan (2013) concluded that public health spending promotes economic growth through human capital improvements.

Contrarily, Mehrara and Musai (2011) found no significant relationship between health spending and economic growth in oil-exporting nations. Rosa and Pueyo (2006) even found a negative association between health expenditure and economic growth. In China, Liu and Zhang (2007) and Sun (2014) observed a negative impact of public health expenditure on economic growth.

2.3. Summary

The literature review reveals a general consensus that increased public health spending positively correlates with improved health outcomes, typically reflected in reduced mortality rates globally. The relationship between health expenditures and economic growth also garners substantial support, albeit with variability depending on regional

economic conditions and policies. This study will explore the impact of public health expenditures on health outcomes and economic growth in China's coastal cities, using mortality rates and per capita GDP as indicators. This research aims to provide insights into optimizing health expenditure for better health and economic prosperity.

3. Methodology

The second is the correlation between public health expenditure and economic growth. According to the literature review in Chapter 2, public health expenditure has a positive effect on health capital and economic growth. Is this argument statistically demonstrable? In this chapter, we take the research results of previous scholars as the theoretical basis, select the panel data of coastal areas from 2013 to 2022 (2023 has not been fully released), build an econometric model, and empirically analyze whether public health expenditure has a significant impact on health capital and economic development.

This paper uses the econometric method to conduct the empirical test, which mainly includes four aspects: (1) the theoretical model of variables is briefly introduced, and the independent variables, dependent variables and functional relations are described. (2) Find the variable data, and delete the missing data. (3) Observe the collated data, make simple research hypotheses and construct regression models according to the theoretical basis of the previous analysis. (4) The significance of explanatory variables was analyzed by descriptive statistics. (5) Empirical analysis and robust test of the model to test the reliability of the regression results.

3.1. Public Health Expenditure and Health Capital

Research theory Grossman(1972) incorporated health into the research framework of human capital for the first time, extended Becker's (1974) household production function into health production function, and established the theory of health capital demand. Grossman assumed that health is a durable capital good, and people have a certain stock of health at birth. The model of health production function given by Grossman is as follows:

$$H = H(X) \quad (1)$$

Where H represents the individual's physical health status, and X represents the vector affecting health status, which includes the following factors: medical treatment level, lifestyle, income level, education level, genetic factors, environmental endowments (such as living conditions, air, water, soil and other environmental pollution levels), and the time invested to improve health status.

3.2. Research Hypothesis

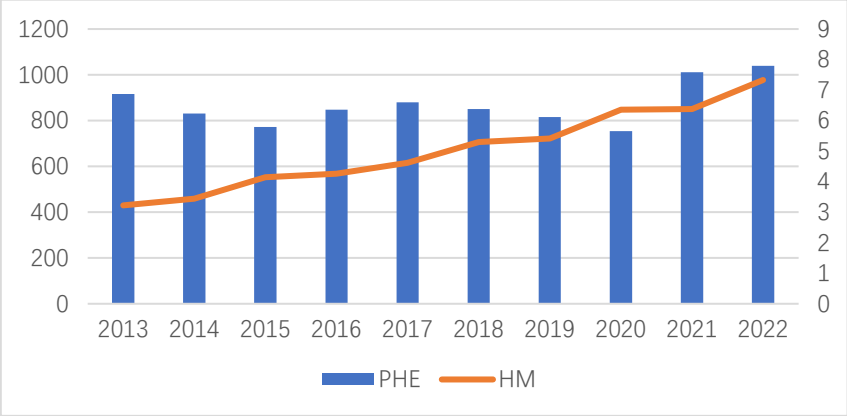

Figure 1. Expected relationship between PHE and HM.

We temporarily use Hebei Province as the benchmark data to observe the impact of public health expenditure on health capital and economic growth, and make the following hypotheses:

The increase of public health expenditure has a positive effect on health capital, it has a negative correlation with population mortality, as illustrated in Figure 1.

3.2.1. Model Construction

Based on Grossman's theoretical model, Filmer et al.(1999) constructed the overall health production function. The individual variables represented by vector X in the formula H =H(X) are transformed into a group of variables representing economy, society, education and health, namely health production

The function can be expressed as: H=H(S,Y,E,M,Z), where S,Y,E,M,Z respectively represent a group of variables that reflect people's society, economy, education, medical treatment and other variables that have an impact on health. The specific function form can be expressed as:

$H=A\ S^{\alpha}Y^{\beta}E^{\gamma}M^{\eta}Z^{\theta}$ -- A represents the estimated value of the initial social health status. After logarithmic processing, we obtain the health level function of its coastal areas:

$$Ln(H)=LnA+\alpha LnS+\beta LnY+\gamma LnE+\eta LnM+\theta LnZ \quad (2)$$

According to the augmented endogenous economic growth model, the following estimation equation can be obtained by adding the random variable ε :

$$LnY_{it}=LnA_{it}+\alpha LnL_{it}+\beta LnK_{it}+\gamma LnH_{it}+\eta LnC_{it}+\theta LnE_{it}+\varepsilon \quad (3)$$

Where i denotes different regions and t denotes different years.

3.2.2. Data Source and Variable Description

The data in this chapter are all from the Statistical Yearbooks, China Population and Employment Statistical Yearbooks and China Health Statistical Yearbooks issued by various regions in China from 2013 to 2022, and the data type is panel data. Among them, public health expenditure is the explanatory variable, health capital is the explained variable, and economic, education, medical services and other variables are the control variables. We use the following indicators to measure these three variables:

Population mortality (HM) - a measure of health status H. Due to the complexity of human structure and physical condition, it is difficult to objectively measure people's health level. If the life span is selected as the indicator, the economic situation may become the most important reason, and the variance is large, which will adversely affect our data test. In view of the statistics of China's population, it will be more comprehensive and objective to measure the health level by population mortality.

Public health expenditure (PHE), we take the amount of public health expenditure per capita as the measure. On the one hand, to avoid excessive standard deviation, on the other hand, to make the data more tractable.

We measured economic, educational, medical and social factors by GDP per capita, the proportion of illiterate population, the total number of medical institutions and the proportion of urban population, respectively, as defined in the following table 1:

Table 1. Definition of variables.

Name of variable	Variable symbol	Variable definition
Health level (explained variable)	HM	Ratio of deaths to the average total population for the period (%)
Health expenditure (explanatory variable)	PHE	Public health expenditure of coastal provinces, autonomous regions and municipalities directly under the Central Government (RMB 100 million)

Economic variables (control variables)	PGDP	Per capita GDP of coastal provinces, autonomous regions and municipalities (RMB)
Education level (control variable)	EDU	Percentage of illiterate population in coastal provinces, autonomous regions and municipalities (%)
Medical services (control variable)	MS	Number of medical institutions in coastal provinces, autonomous regions and municipalities
Social factors (control variable)	SF	Proportion of urban population to total population in coastal provinces, autonomous regions and municipalities (%)

3.3. Public Health Expenditure and Economic Growth

3.3.1. Research Theory

In the mid-1980s, research on economic growth reached its third climax. The endogenous growth theory, represented by Romer, Lucas and others, provided a new way for scholars to study economic growth. The general form of economic growth function under this model is as follows:

$$Y=F(L,K)=AL^{\alpha}K^{\beta} \quad (4)$$

Barro (1996) constructed an economic model with health capital for the first time on the basis of endogenous economic growth theory. In this model, he analyzed the impact of health capital on educational capital and physical capital, as well as the interaction among health capital, educational capital and physical capital.

3.3.2. Model Construction

Based on the endogenous growth model established by Barro (1990) and Sala-I-Martin(1995), this paper incorporates government health expenditure in coastal areas as a variable affecting economic growth into the production function model. However, the production function of coastal areas in this paper is different from Barrow (1990) model in that we emphasize more that government health expenditure can improve the health level of workers, thus promoting economic development. The initial endogenous growth model is set as follows:

$$Y=F(L,K,H)=AL^{\alpha}K^{\beta}H^{\gamma} \quad (5)$$

Where Y represents total output, L, K and H represent labor input, physical capital input and government health expenditure, respectively. α, β and γ represent the elasticity coefficients of capital factor input, human factor input and government health expenditure, respectively. Coefficient A represents Total factor productivity (also known as total factor productivity), that is, excluding capital and labor input factors, all other factors affecting total output, including institutional factors, knowledge, education, technical training, economies of scale, organization and management, regional resource endowment, etc. Take the logarithm of both sides of the model as follows:

$$LnY=LnA+\alpha LnL+\beta LnK+\gamma LnH \quad (6)$$

In order to enhance the explanatory power of the model, we add two variables: consumption variable (total social consumption) C and trade variable E (export value of goods according to location). Therefore, the model considers the following five factors that affect China's economic growth: L is used to represent the labor input in coastal areas, K is used to represent the physical capital input in coastal areas, H is used to represent the government health expenditure in coastal areas, C is used to represent the total retail sales of consumer goods in coastal areas, and E is used to represent the total export in coastal

areas. By adding LnC and LnE terms on the right side of the equation of this model, the extended endogenous growth function model is obtained:

$$LnY=LnA+\alpha LnL+\beta LnK+\gamma LnH+\eta LnC+\theta LnE \quad (7)$$

According to the expanded endogenous economic growth model, the following estimation equation can be obtained by adding the random variable ε :

$$LnY_{it}=LnA_{it}+\alpha LnL_{it}+\beta LnK_{it}+\gamma LnH_{it}+\eta LnC_{it}+\theta LnE_{it}+\varepsilon \quad (8)$$

Where i denotes different regions and t denotes different years.

3.3.3. Data Source and Variable Description

The data in this chapter are all from the Statistical Yearbook, China Statistical Yearbook and China Health Statistical Yearbook released by various regions in China from 2013 to 2022, and the data type is panel data. Among them, public health expenditure is the explanatory variable, the total GDP of each province is the explained variable, and labor input, capital input, total social consumption and total export are the control variables. We used the following indicators to measure these three variables

Total output GDP (Y) : Total GDP of provinces, autonomous regions and municipalities in coastal areas for the year (100 million yuan)

Labor input (L) : total number of employees (ten thousand) at the end of the year in all provinces, autonomous regions and municipalities in coastal areas.

Physical capital input (K) : total investment in fixed assets of provinces, autonomous regions and municipalities in coastal areas in the current year (100 million yuan)

Government health input (H) : the expenditure of medical and health expenses of all provinces, autonomous regions and municipalities in coastal areas in the current year (100 million yuan), including health expenses, food and drug supervision and administration fees, family planning fees, medical funds for administrative institutions, subsidies for basic medical insurance funds, etc.

Total consumption (C) : total retail sales of consumer goods of all provinces, autonomous regions and municipalities in coastal areas in the current year (100 million yuan).

Total exports (E) : total exports of goods in the current year at the location of the operating units in the provinces, autonomous regions and municipalities directly under the Central Government in the coastal areas (100 million yuan).

α, β and γ represent the elasticity coefficients of labor input (L), physical capital input (K) and government health input (H), respectively, while A represents total factor productivity, that is, the productivity of pure technological progress excluding the above-mentioned tangible factors of production. The selection of specific variables is explained in the following table 2:

Table 2. Definition of variables.

Variable name	Variable symbol	Variable definition
Total output (explained variable)	Y	Total GDP of coastal provinces, autonomous regions and municipalities over the years 2013-2022 (100 million yuan)
Health expenditure (explanatory variable)	H	Government medical and health Expenses of Coastal Provinces, Autonomous regions and municipalities over the Years 2013-2022 (RMB 100 million)
Labor input (control variable)	L	Total number of employees in coastal provinces, autonomous regions and municipalities at the end of the years from 2013 to 2022 (ten thousand)

Capital input (control variable)	K	Total investment in fixed assets in coastal provinces, autonomous regions and municipalities over the years 2013-2022 (100 million yuan)
Total consumption (control variable)	C	Total retail sales of consumer goods in provinces, autonomous regions and municipalities in coastal areas 2013-2022 (100 million yuan)
Total exports (control variable)	E	2013-2022 Total exports of goods in the year at the location of the operating units of each province, autonomous region and municipality directly under the Central Government in coastal areas (100 million yuan)

4. Empirical analysis

In the estimation, the public health expenditure, per capita GDP and the number of health care institutions are all taken as log values. The value from Descriptive statistics is given in the table 3:

Table 3. Descriptive Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
hm	110	6.115	905.	4.23	9.04
edu	110	3.597	1.602	9.	7.33
sf	110	7.5004	80.093	45.11	89.91
lnphe	110	6.15	708.	4.243	7.641
lnpgdp	110	11.156	434.	10.182	12.1
lnms	110	10.115	989.	8.453	11.41

The standard deviations of the listed variables are all relatively small, indicating good data quality.

The pairwise correlations are given in table 4:

Table 4. Pairwise correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) hm	1.000					
(2) lnphe	-0.231*	1.000				
	(0.015)					
(3) lnpgdp	-0.498*	0.312*	1.000			
	(0.000)	(0.001)				
(4) edu	0.225*	0.082	-0.072	1.000		
	(0.018)	(0.392)	(0.452)			
(5) lnms	0.276*	0.713*	-0.301*	0.241*	1.000	
	(0.003)	(0.000)	(0.001)	(0.011)		
(6) sf	-0.126	-0.016	0.258*	-0.134	-0.222*	1.000
	(0.191)	(0.871)	(0.006)	(0.164)	(0.020)	

In order to avoid the collinearity between variables, the econometric stata software was used to test the correlation of variables. The correlation matrix coefficients of variables are shown in the table. It can be seen from the table that the correlation coefficients of variables are below 0.5, indicating that there is no serious collinearity between variables, so regression analysis can be carried out. Values from VIF test are illustrated in table 5:

Table 5. VIF Test.

Variable	VIF	1/VIF
lnms	5.84	0.171098
lnphe	5.59	0.178872
lnpgdp	2.98	0.335097
edu	1.12	0.895102
sf	1.11	0.900378
Mean VIF	3.33	

The variance inflation factor VIF in the table is lower than 10, so there is no multicollinearity, so the next study is carried out.

4.1. Regression model

The data used in this paper are panel data, and the regression methods of panel data mainly include fixed effect, random effect and mixed effect. In order to test which method is more suitable for this study, we first use the econometric software stata to conduct F test, LM test and Hausman test. 3 different test comparison is given in table 6:

Table 6. Test Comparison.

Test method	Related relationship	P-value	Model selection
F test	F (10 hanjie xuebao/transactions) = 30.48	Prob > F = 0.0000	FEM is better than HM
LM test	Chibar2 (01) = 253.86	Prob > chibar2 = 0.0000	REM is better than HM
Hausman test	Chi2 = 2.16	Prob > chi2 = 0.8262	REM is better than FEM

The F-test indicates that the fixed effect is better than the mixed effect, the LM test indicates that the random effect is better than the mixed effect, the Hausman test indicates that the fixed effect is better than the mixed effect, the F-test indicates that the fixed effect is better than the random effect, and the Hausman test indicates that the random effect is better than the fixed effect. The following is the analysis of regression results with and without lnphe, the core explanatory variable.

4.2. Regression analysis

The effect analysis derived from Regression test are illustrated in table 7:

Table 7. Regression Table.

	(1)hm	(2)hm
lnpgdp	-1.585***	-0.423
	(-7.757)	(-1.164)
edu	0.047	0.049
	(0.947)	(1.045)
lnms	0.085	0.721**
	(0.340)	(2.552)
sf	0.000	0.000
	(0.289)	(0.260)
lnphe		-0.914***
		(-3.727)
_cons	22.754***	8.971*

	(7.149)	(1.905)
N	110	110
R^2	0.8793	0.2651
F	439.21	625.12
	***p<0.01,**p<0.05,*p<0.10	

***, **, and * indicate significance at the 1%, 5%, and 10% levels. Values in parentheses are absolute values of t-statistics.

From the overall regression results, the adjusted fitting coefficients are all above 85%, indicating that the regression results have a good fit. The selected core explanatory variables have a large degree of explanation for the explained variables, and the F statistic value greatly exceeds the critical value, indicating that the joint significance between the variables is strong. The public health expenditure variable has passed the significance test. The public health expenditure variable passed the significance test. The regression results have great credibility.

According to the regression results of variables, we can see that public health expenditure as an explanatory variable makes the results very significant and passes the test at the significance level of 1%, and most variables also pass the test. The result analysis is as follows:

The sign of Lnpgdp is negative, indicating that with the increase of GDP per capita and the continuous improvement of people's living standards, the mortality rate will gradually decline. The correlation coefficient is -1.585, that is, under the premise of keeping other conditions unchanged, every percentage point increase of GDP per capita will lead to 1.585 percentage points decrease of mortality rate.

The sign of lnphe is negative, indicating that with the increase of public health expenditure, the mortality rate will gradually decrease, and the correlation coefficient is -0.914. In this regression analysis, we added other control variables, showing that a 1 percentage point increase in public health expenditure will lead to a 0.914 percentage point decrease in mortality, holding education, social, economic, and medical factors constant.

The coefficient of the proportion of urbanization population is 0, indicating that urbanization does not affect the health capital.

The factor of medical and health institutions passed the test at the significance level of more than 5%, and the correlation coefficient was 0.721, that is, under the premise of keeping other conditions unchanged, every percentage point increase in the number of medical and health institutions would lead to 0.721 percentage point increase in the mortality rate.

The correlation coefficient of education factor was 0.429, that is, under the premise of keeping other conditions unchanged, every percentage point increase in the number of medical institutions would lead to a 0.429 percentage point increase in mortality. Therefore, increasing the level of education would increase the mortality rate.

Robustness test is defined as table 8:

Table 8. Robustness test.

VARIABLES	HM
lnphe	-1.231***
	(0.217)
lnpgdp	0.210
	(0.258)
edu	0.0434
	(0.0428)
lnms	0.891***
	(0.158)
Constant	2.174

	(3.126)
Observations	110
R-squared	0.459

Notes_Titles(Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1).

We can see that the correlation coefficient sign of the relevant variables: public health expenditure, illiteracy rate, number of medical institutions did not change and therefore passed the test.

4.3. Public health expenditure and economic growth

4.3.1. Data collation and analysis

In the estimation, all variables (including explanatory variables, explained variables and control variables) are taken as log values. In this way, on the one hand, considering the nonlinear relationship between each factor and the economy, the logarithm is taken to facilitate model estimation; On the other hand, through such data processing, it perfectly fits CobbDouglas production function and endogenous economic growth model, which has a better fitting degree to the data and is closer to the reality. The value from Descriptive statistics is given in the table 9:

Table 9. Descriptive Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
lny	110	10.343	879.	8.044	11.768
lnphe	110	6.15	708.	4.243	7.641
lnl	110	7.821	788.	6.244	8.875
lnk	110	9.901	857.	7.9	11.134
lnc	110	9.394	912.	6.995	10.712
lne	110	8.548	1.396	5.557	11.182

The standard deviations of the listed variables are all relatively small, indicating good data quality.

The pairwise correlations are given in table 10:

Table 10. Pairwise correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) lny	1.000					
(2) lnphe	0.913 *	1.000				
	(0.000)					
(3) lnl	0.832 *	0.828 *	1.000			
	(0.000)	(0.000)				
(4) lnk	0.822 *	0.805 *	0.851 *	1.000		
	(0.000)	(0.000)	(0.000)			
(5) lnc	0.989 *	0.897 *	0.848 *	0.818 *	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)		
(6) lne	0.903 *	0.748 *	0.748 *	0.788 *	0.893 *	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

*** p<0.01, ** p<0.05, * p<0.1

In order to avoid the collinearity between variables, the econometric stata software was used to test the correlation of variables. The correlation matrix coefficients of variables are shown in the table. It can be seen from the table that the correlation coefficients of variables are below 1, indicating that there is no serious collinearity between variables, so regression analysis can be carried out. Values from VIF test are illustrated in table 11:

Table 11. VIF test.

Variable	VIF	1/VIF
lnc	13.14	0.076090
lnphe	6.45	0.154960
lne	6.05	0.165419
lnl	5.11	0.195824
lnk	4.80	0.208315
Mean VIF	7.11	

The variance inflation factor VIF in the table is all lower than 10, so there is no multicollinearity.

4.3.2. Regression model

The data used in this paper are panel data, and the regression methods of panel data mainly include fixed effect, random effect and mixed effect. In order to test which method is more suitable for this study, we first use the econometric software stata to conduct F test, LM test and Hausman test. 3 different test comparison is given in table 12:

Table 12. Test Comparison.

Test method	Related relationship	P-value	Model selection
F-test	F (10 hanjie xuebao/transactions) = 11.65	Prob > F = 0.0000	FEM is better than HM
LM test	Chibar2 (01) = 35.09	Prob > chibar2 = 0.0000	REM is better than HM
Hausman test	Chi2 = 10.80	Prob > chi2 = 0.0554	REM is better than FEM

The F-test indicates that the fixed effect is better than the mixed effect, the LM test indicates that the random effect is better than the mixed effect, the Hausman test indicates that the fixed effect is better than the mixed effect, the F-test indicates that the fixed effect is better than the random effect, and the Hausman test indicates that the random effect is better than the fixed effect. The following is the analysis of regression results with and without lnphe, the core explanatory variable.

4.3.3. Regression analysis

The effect analysis derived from Regression test are illustrated in table 13:

Table 13. Regression Table.

	(1)lny	(2)lny
lnl	-0.127**	-0.146***
	(-2.057)	(-3.393)
lnk	-0.094	-0.026
	(-1.580)	(-0.630)
lnc	0.885***	0.328***
	(10.767)	(4.148)
lne	0.228***	0.131***
	(4.030)	(3.251)
lnphe		0.417***
		(10.194)
_cons	2.002***	4.979***

	(2.882)	(8.844)
N	110	110
R^2	0.808	0.909
F	99.674	186.909
	***p<0.01,**p<0.05,*p<0.10	

***, ** and * indicate the significance level at 1%, 5% and 10%, and the values in parentheses are the absolute values of the t-statistics.

From the overall regression results, the adjusted fitting coefficients are all above 85%, indicating that the regression results have a good fit. The selected core explanatory variables have a large degree of explanation for the explained variables, and the F statistic value greatly exceeds the critical value, indicating that the joint significance between the variables is strong. The public health expenditure variable has passed the significance test. The public health expenditure variable passed the significance test. The regression results have great credibility.

According to the regression results of variables, we can see that public health expenditure as an explanatory variable makes the results very significant and passes the test at the significance level of 1%, and most variables also pass the test. The result analysis is as follows:

The sign of Lnphe is positive, indicating that with the increase of public health expenditure, the economic aggregate is increasing, which passes the test at the significance level of 1%. The correlation coefficient is 0.417, if other conditions remain unchanged, every percentage point increase in public health expenditure will lead to 0.417 percentage point increase in economic output.

The sign of Lnl is negative, indicating that as the labor force increases, the total economic output decreases. This may be due to the reason of diminishing marginal product of labor, which leads to a decrease in output, telling us that more labor is not better. The correlation coefficient is

− 0.146, which means that a one percentage point increase in the number of workers will lead to a 0.146 percentage point decrease in economic output, ceteris paribus.

The sign of Lnk is negative, indicating that the economic aggregate is decreasing with the increase of fixed asset investment. This may be due to the reason of diminishing marginal product of capital, which leads to a decrease in output, telling us that more amount of fixed asset investment is not always better. The correlation coefficient is -0.026, which means that a one percentage point increase in the number of workers will lead to a 0.026 percentage point decrease in economic output, ceteris paribus.

The sign of Lnc is positive, indicating that the economic aggregate is increasing with the increase of consumption. In macroeconomics, consumption equals aggregate demand, and aggregate demand equals aggregate output, so demand accounts for most of the economy. The correlation coefficient is 0.885, which means that a one percentage point increase in consumption will lead to an increase in economic output of 0.885 percentage points, ceteris paribus.

The sign of Lne is positive, indicating that as exports increase, the economic aggregate is increasing. In macroeconomics, the economic aggregate includes the volume of exports, so the increase in the volume of exports will lead to the increase in the economic aggregate. At the significance level of 1%, the correlation coefficient is 0.131, that is, keeping other conditions unchanged, every percentage point increase in export volume will lead to an increase in economic output of 0.131 percentage points.

Robustness test is defined as table 14:

Table 14. Robustness test.

VARIABLES	Lny
lnphe	0.179***
	(0.0373)

lnl	-0.0955***
	(0.0313)
lnk	0.0508*
	(0.0264)
lnc	0.859***
	(0.0307)
Constant	1.412***
	(0.133)
Observations	110
R-squared	0.984

Notes_Titles (Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1).

We can see that the symbol of correlation coefficient between public health expenditure and lny has not changed, so lnphe passes the test.

5. Research limitation and innovation

5.1. Research limitation

As for the research on the correlation between public health expenditure, health capital and economic growth, the paper taking coastal areas of China as an example may have the following research deficiencies:

Insufficient selection of regional samples: The paper may not cover the coastal cities and county-level cities widely and representative enough, but only analyzes the relevant provinces. If the location is detailed, the analysis can be more realistic and the generalizability of the conclusions can be avoided.

Short time spans: For the relationship between economic growth, public health spending, and health capital, short time spans may not provide a complete picture of the long-term effects and interactions between these variables.

5.2. Research innovation

The innovation of this paper may include the following aspects:

Pay attention to health spending in China's coastal areas: China's coastal areas are important for economic development and international trade, but they also face public health challenges. By selecting coastal areas as research subjects, we can more accurately understand the impact of public health spending on health capital and economic growth, thereby providing guidance for policy making in the region.

Examined the relationship between public health expenditure and health capital: this paper focuses on the impact of public health expenditure on health capital, discusses the role of public health expenditure in improving people's health level and reducing population mortality, and verifies this relationship through data analysis and empirical research.

Explores the relationship between public health spending and economic growth: In addition to focusing on health capital, the paper also explores the impact of public health spending on economic growth. By studying the impact of public health expenditure on GDP, it provides empirical support for the relevant policies of national economic growth.

These innovations can help to enrich the understanding of the relationship between public health expenditure, health capital and economic growth, and provide evidence and suggestions for the formulation of relevant policies.

6. Conclusion

First, the findings provide strong support for the idea that higher public health spending boosts health capital. Increased health spending not only meets urgent healthcare needs but also helps create a workforce that is healthier and more productive by lowering death rates and increasing overall health outcomes. This is consistent with

Grossman's theory of health as a type of human capital, which holds that investing in health is essential to building a strong labor force, which is necessary for long-term economic growth. Second, the data shows a strong positive relationship between economic growth and public health spending. The results show that the GDP of the coastal areas under study rises in direct proportion to increases in health spending. This correlation challenges the conventional wisdom that health spending is just a consumptive part of government budgets, while simultaneously reinforcing the significance of health expenditure as a major economic driver. Rather, it presents health spending as a calculated investment that generates significant financial returns, so endorsing the theoretical models of Barro and Sala-i-Martin regarding the endogenous processes that connect public health spending to economic growth.

In existing studies, researchers have proposed many ideas for improving health outcomes in the world or in China, such as changing government monitoring mechanisms, improving healthcare billing (DRG payments), or broader health insurance coverage. The paper looks at public spending, health outcomes, and economic growth together and concludes that there is a solid case for more public health spending as a dual strategy for improving health outcomes and promoting economic expansion. It urges policymakers to view health spending as an important investment in the region's economic future and a way to improve public well-being. This strategy may be particularly useful for regions trying to strike a balance between social health requirements and economic development and endeavoring to emulate the achievements of China's coastal provinces.

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